

Project Interface Requirements Process including Shuttle Lessons Learned

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Abstract

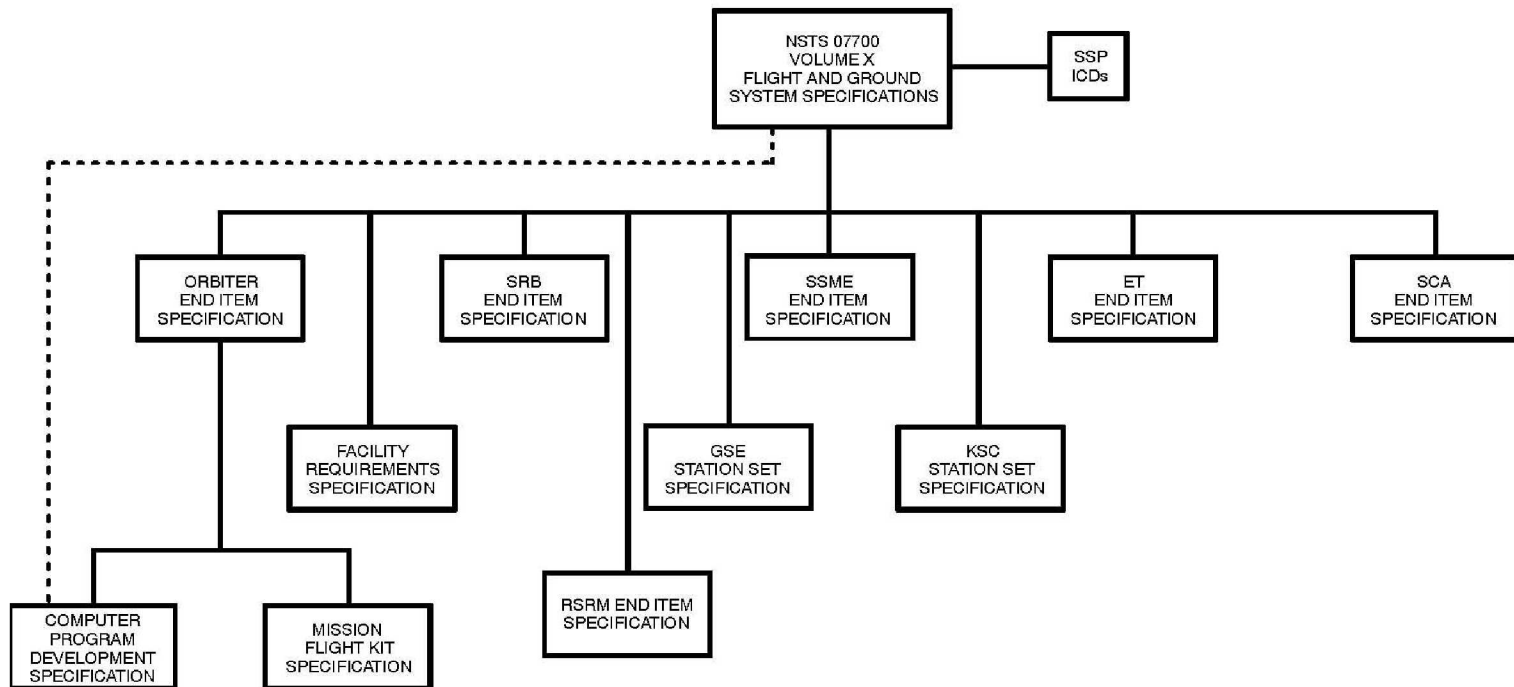
Most failures occur at interfaces between organizations and hardware. Processing interface requirements at the start of a project life cycle will reduce the likelihood of costly interface changes/failures later. This can be done by adding Interface Control Documents (ICDs) to the Project top level drawing tree, providing technical direction to the Projects for interface requirements, and by funding the interface requirements function directly from the Project Manager's office. The interface requirements function within the Project Systems Engineering and Integration (SE&I) Office would work in-line with the project element design engineers early in the life cycle to enhance communications and negotiate technical issues between the elements. This function would work as the technical arm of the Project Manager to help ensure that the Project cost, schedule, and risk objectives can be met during the Life Cycle. Some ICD Lessons Learned during the Space Shuttle Program (SSP) Life Cycle will include the use of hardware interface photos in the ICD, progressive life cycle design certification by analysis, test, & operations experience, assigning interface design engineers to Element Interface (EI) and Project technical panels, and linking interface design drawings with project build drawings.

Synopsis

- This presentation will provide you with specific "lessons learned" approaches to ensure Interface Requirements lead the way in communicating Project element requirements across the interfaces.

Space Shuttle Program ICDs Began as Specifications

FIGURE 3-1
SPACE SHUTTLE SPECIFICATION TREE



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Specification Definition

- Statement of particulars such as performance, characteristics, requirements, and configuration for a given element of hardware/software.

Verification

- Process used to verify that the specifications have been met
- Occurs during development , test, and evaluation phases



Certification

- Approval of the verification results by management



Interface Control Document/ Interface Revision Notice Definition

- Drawings/Documentation that record the common design features between two or more interfacing designs.
- Standard IRN form used to record changes to an approved ICD

Program ICDs Used To Control Interfaces Between Elements

- Shuttle System/Vertical Assembly Building
- Shuttle System/Launch Pad
- Flight Vehicle/LPS Computational Systems
- Space Shuttle/KSC RF Comm & Tracking C/O
- JSC/USAF Space Shuttle SCF RF Comm & Track
- Shuttle/GSFC Space Shuttle RF Comm & Track
- Shuttle Vehicle/Ground Range Safety System
- Shuttle Vehicle Mold Lines and Protuberances

Program ICDs Used To Control Interfaces Between Elements

- Orbiter/KSC Landing Station
- Orbiter Processing Facility/Orbiter Main & C/O
- Orbiter/Hypergolic Station
- Orbiter Landing/Safing & Deservicing Stations
- Orbiter & Carrier Aircraft/Mate-Demate I/F
- Orbiter Vehicle/External Tank
- Orbiter Vehicle/Solid Rocket Booster
- Orbiter Vehicle/Carrier Aircraft

Program ICDs Used To Control Interfaces Between Elements

- Orbiter Vehicle/Carrier Aircraft
- External Tank/Solid Rocket Booster
- External Tank/Receiving, Storage & C/O
- Solid Rocket Booster/Receiving Processing
- Space Shuttle Orbiter Vehicle/Main Engine



Present IWG Process

- Tier I
 - Change → Process IRN → Approve → Process CR → Approve → Incorporate IRN
- Tier II
 - **Change** data affecting interface from NASA/Contractor Projects and IPRs, LCNs, CRs, MRs, and RCNs
 - **Process IRN:** Author IRN → Release IRN → Evaluate IRN → Concur IRN
(Concur IRN not required for Waiver IRNs)
 - **Approve** IRN: IWG Chair
 - **Process CR:** Author C → Release CR → Evaluate CR → Concur CR
 - **Approve** CR: SICB Chair
 - **Incorporate IRN** in ICD



Sources That Reveal Interface Changes

- Project Systems Engineers
- Safety walk-downs at KSC
- Material Review Boards
- Special PRCBs
- Change Requests
- Requirement Change Notices (ORMSD)
- Launch Commit Criteria
- Audits

Need Interface Design Engineers to Work with Both Projects

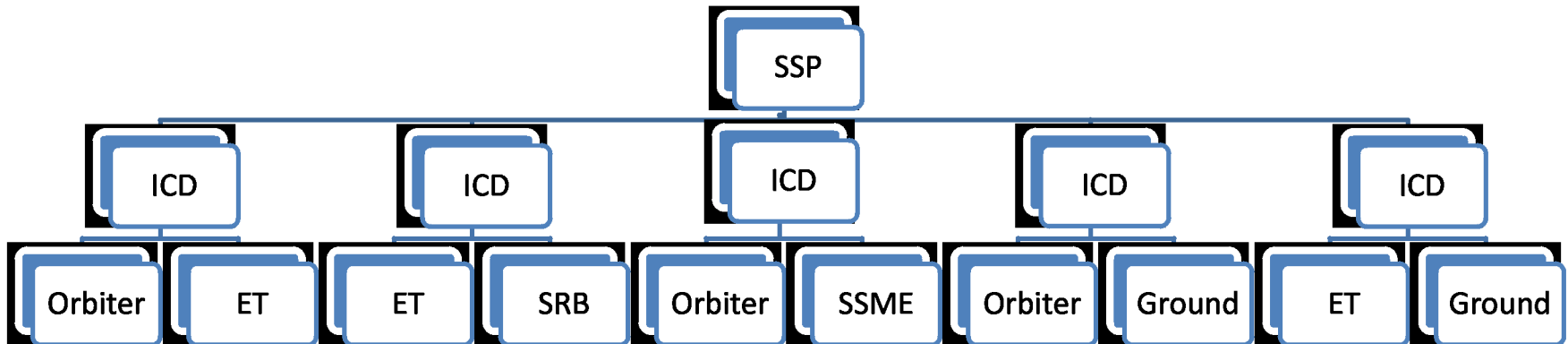
- Element Projects integrate across the interface with the other Project
- Need additional integration early from SE&I working in –line with both Projects
 - Communicate with both Projects
 - Negotiate as required
 - Design analysis
 - Technical analysis
 - Hazards analysis

Need Interface Design Engineers to Work With Both Projects (cont'd)

- One Project could design, build and maintain the interface hardware
- Drawing flagnotes reference across interface



Add ICD to Drawing Tree for Launch Configuration



Verify Interface Requirements Early

- Use certified values in ICD
- Certification determined during life cycle by
 - Analysis
 - Test
 - Operations

Streamline IWG Process

- Remove IWG/IRN tasks from process
 - Author IRN
 - Release IRN
 - Evaluate IRN
 - Concur IRN
 - Approve IRN
 - Incorporate IRN in ICD



Revised Process

- Tier I
 - Change → Process CR → Approve → Incorporate CR in Projects
- Tier II
 - **Change** data affecting interface from NASA/Contractor Projects and IPRs,LCNs, CRs, MRs, and RCNs
 - **Process CR:** Author CR → Release CR → Evaluate CR → Concur CR
 - **Approve CR:** (SICB Chair)
 - **Incorporate CR in Projects** (Directive Action)



Living Interface Requirements Thru-out The Project Life Cycle

- Alpha and Omega
- Requirements/Specifications
- Design
- Development
- Test
- Evaluation
- Production
- Operations

ICDs are a Technical Process

- Not only a documentation process
- Involve design analysis with system experts
- Several systems can go thru each interface
 - Liquid/Gas (thermal)
 - Electrical (volts, amperage, resistance)
 - Data communication (data rate, type)
 - Structural (loads)



Work with Aero, Thermal & Loads Panels

- Submit IRNs to Panels for analysis
- Verify that change is ok

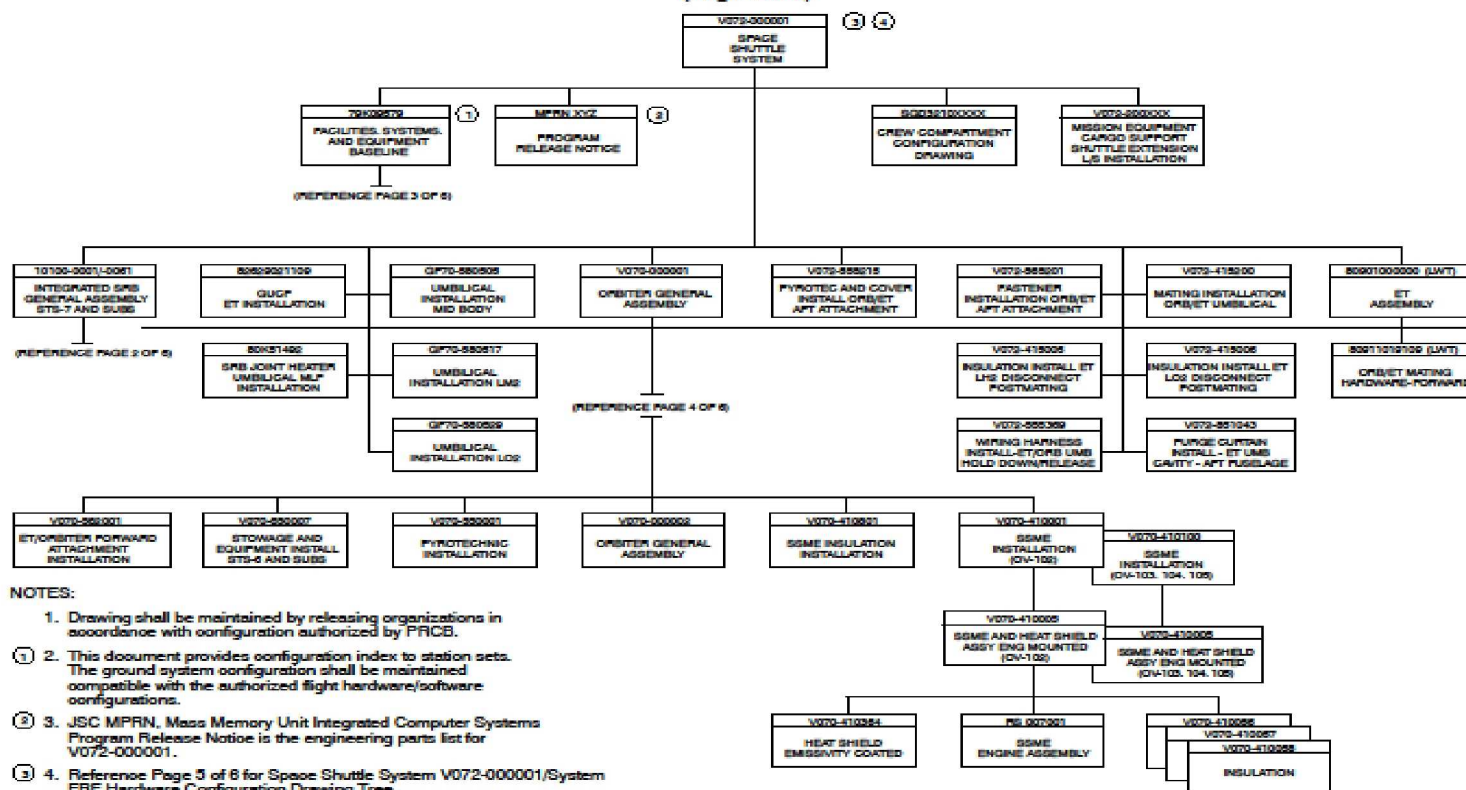


Shuttle Top Assembly Drawing Tree

FIGURE 3-2

SPACE SHUTTLE TOP ASSEMBLY DRAWING TREE (EFFECTIVITY: STS-55, STS-51, STS-56, AND SUBS)

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Maximize Depiction of the Project Systems Interface in the ICDs

- A project may design and build parts on the other side of the interface
- Add ownership reference line
- Add actual separation interface
- Reference Project systems drawings in the ICD
- Use good judgment to determine the depth
- Use functional interface of two (2) elements
 - Regardless who owns hardware

Living ICD during Project Life

- Monitor Interface Data in Mission Control
- OMRSD based on ICD plus Operations Experience
- Expand Life Cycle scope to design, development, test, verification, production, and operations.

Direct Funds Thru Integration Activity

- Initially in Shuttle Integration dollars were directed thru Orbiter Project contract
- Eventually, Technical Direction was given to Integration in the contract



Audit Process Periodically

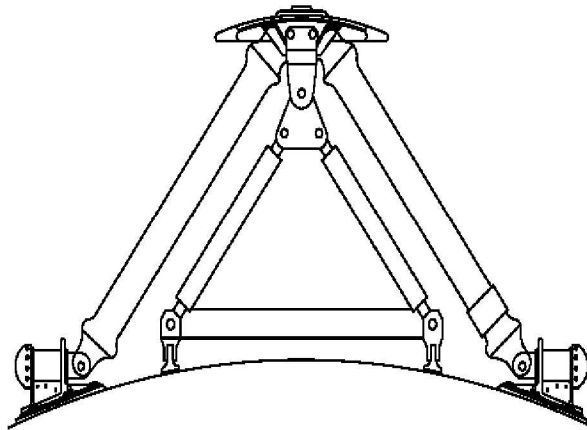
- Use Product Development Plan to audit process
- Send questions to contractor
- Face to face meeting on-site best
- Obtain answers from contractors
- Issue NASA findings
- Track the implementation change

Reduce Change Authority Duplication Where Process Integrity Remains

- SICB controls ICDs
- SPRCB controls OMRSDs
- Waivers come in on OMRSDs that also affect ICDs
- Rationale is heard at SPRCB
- Waiver is approved at SPRCB
- IRN/ICD can be OSB based on previous authority
- Can also simply establish a log of documentation only waivers approved by IWG chair as delegated by the SICB Chair.

Add Interface Photos to ICDs

- Orbiter/ET Forward Attachment



EO-1 ORBIT



Conclusions

- Excellent Design Engineering and Interface Control is needed early in the Program life cycle to minimize costs and hazards.
- Program SE&I Integration Design Engineers should work as a team with the Project Systems Engineers starting early in the Program Life Cycle – design, development, test, verification, production, and operations.